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REPORTS ON RARE, THREATENED, AND ENDANGERED VASCULAR PLANTS: DISCUSSION AND GUIDELINES

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SOUTHEAST REGION

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REPORTS ON RARE, THREATENED, AND ENDANGERED VASCULAR PLANTS: DISCUSSION AND GUIDELINES

Research/Resources Management Report No. 33

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INTRODUCTION

The Federal Endangered Species Act of 1973, state programs, and the efforts of private environmental organizations have resulted in the compilation of numerous reports on rare vascular plants. While all of these have a common goal--the reporting of rare taxa, their endangerment, distribution, and status--they differ widely in format. Some are simply lists (e.g., the 1975 Smithsonian report on a national level and Pittillo's unpublished 1974 manuscript on a local level). Others are compilations of herbarium label data or photocopies of the labels themselves (e.g., Eastman 1978). Some include information on such parameters as recognition (e.g., Parr and Taylor 1978, Roeder and Evans 1978), nomenclature (e.g., Cooper and others 1977), population status (e.g., EGG, Inc. 1977, 1978), distribution (e.g., Goff and others 1975), habitat (e.g., Pittillo and Govus 1978, Storks and Crow 1978), or management (Holland and Schramm, in press). Although some regions have developed a single format in a variety of publications (NEBC 1972, used in Storks and Crow 1978 and reports on the other New England states; Massey and Atkinson 1979; Massey and others 1978), there is no wide agreement on what to report or how to categorize it.

This paper discusses information appropriate for rare and endangered species reports. The guidelines presented here were developed for use in Great Smoky Mountains National Park (GRSM), Tennessee and North Carolina, and the examples used to illustrate the guidelines are taken from that region (White, in press, a). Literature is cited in the course of the general discussion but a complete bibliography of rare vascular plant reports has not been attempted (see Lawyer, in press, for such a bibliography).

THE SCOPE OF THIS DISCUSSION

Work on rare species consists of four stages: (1) inventory (collection of herbarium specimens and preparation of a check list); (2) determination of rarity and endangerment, at least in a preliminary sense, including prioritization of further research needs; (3) intensive studies on population biology and ecology of rare species; and (4) recommendation for protection and/or management action. These stages are not necessarily sequential--in particular, stages 1 and 2 are perennial as new information accumulates. Further, if a species is in immediate jeopardy, we cannot await the collection of a large data set before recommending some counter to existing or potential threats.

Of the stages listed above, the guidelines presented in this paper are aimed at stage 2. Several guidelines already exist for the intensive investigation of population biology, ecology, and status review (stage 3--Massey and Whitson 1977; Henifin and others, in press; NEBC 1972). Autecological work has already been carried out for some rare species (Anderson 1980; Baskin and Baskin 1979; Bradshaw and Doody 1978; Dring and Frost 1971; Graber 1980; Macior 1980; Meagher and others 1978; Morse ms.; Namkoong and Roberds 1974; Prentice 1976; Richards 1972; Vivian 1967). There is nearly universal agreement that intensive species population ecology work is of high priority (Baskin and Baskin 1979, Bradshaw and Doody 1978). This report is not meant as a guide for such work; rather, it is intended for reports aimed at a broader level of generalization--the generalization that often precedes and helps prioritize the more intensive work that is needed.

James Massey and colleagues have developed a system for documenting

rare vascular plant records (Massey and Atkinson 1979, Massey and others 1978). A clear strength of this system is the citation of a source (either literature or herbarium specimen) for each item of information. However, the records are presented in outline form. Massey's system is ideal for technical reports and archival records, for which it is here recommended as the best available. The guidelines suggested here are for reports aimed at summarizing this information. For example, specific herbarium records can be reserved for archival storage and summarized in the more general report.

Users of this document may find the following additional reports helpful: Computerization of Herbarium Records at Great Smoky Mountains National Park (Pyle and others 1978) and Computerization of the Vascular Plant Check List at Great Smoky Mountains National Park (White 1980).

RARITY AND ENDANGERMENT: THE CONCEPTS

Rarity and endangerment are not synonymous. They apply to different aspects of plant populations in the landscapes. Rarity is a condition of the relative numbers and distribution of populations and individuals; endangerment is the condition of being vulnerable to extinction. Small populations are more vulnerable to extinction than large populations (Hooper 1971, Terborgh 1974, Bonnell and Selander 1974; Diamond 1975), but the two factors are at least potentially independent. Some rare plants may not be endangered; some relatively common plants are (including, in the eastern United States, Castanea dentata and the aesthetically appealing Orchidaceae).

This idealistic separation of rarity and endangerment breaks down, in a practical sense. Extinction proceeds through population reduction--

hence all endangered species are eventually rare. In addition, lack of knowledge concerning threats necessitates the listing of many species based on rarity only. Rare plants are usually vulnerable to the most basic threat of all--continuing human-caused destruction of populations and habitat--even when no other more subtle or specific factors are known. Given the lack of knowledge and the usual vulnerability of small populations, rarity is the principal criterion used in the construction of many rare and endangered lists. However, species which are not rare may be listed because of some specific vulnerability. In GRSM, commercial exploitation and private gathering threaten such plants as Panax quinquefolium despite a relatively wide distribution compared to most listed plants. This plant is listed at national (Ayensu and DeFilipps 1978) and state levels (Cooper and other 1977, Committee for Tennessee Rare Plants 1978).

Rarity. Rarity has two dimensions (Hardin 1977; Fig. 1): the number of individuals and the number of distinct locations at which the individuals occur (i.e., the number of sites, "stations", or populations). There are several descriptive phrases used for various combinations of the numbers of individuals and sites:

"Local" - very few sites;

"Locally abundant" - few sites but populations large;

"Local and rare" - few sites and plant scarce, even at these sites;

"Scarce" - frequent to scattered locations but very few individuals found.

The use of these terms is not uniform. Hardin (1977) suggested that we should think of population size and number of locations as continuous and independent variables that define a two-dimensional field of relative

Figure 1. Relative rarity in a two-dimensional field (after Hardin 1977).

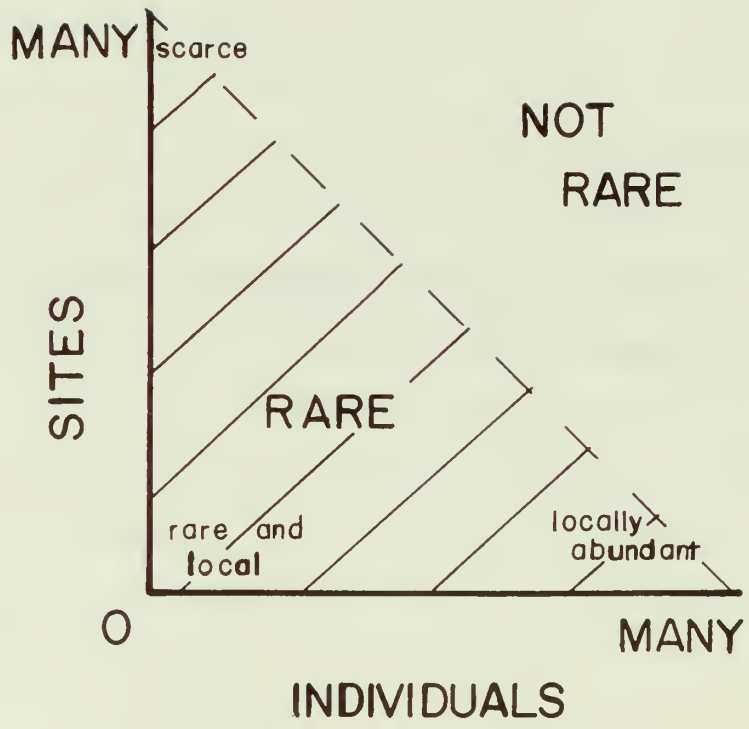
MANY
scarce
NOT
RARE
SITES
RARE
rare and
local
locally
abundant
O
MANY
INDIVIDUALS

Figure 2. Hypothetical dominance-diversity curves (after Whittaker 1972) illustrating problems in the definition of rarity. A. Steep drop-off along species sequence. B. Smooth and gradual decrease along species sequence. The two cases have the same total number of species. See Figure 3 for associated rarity diagrams.

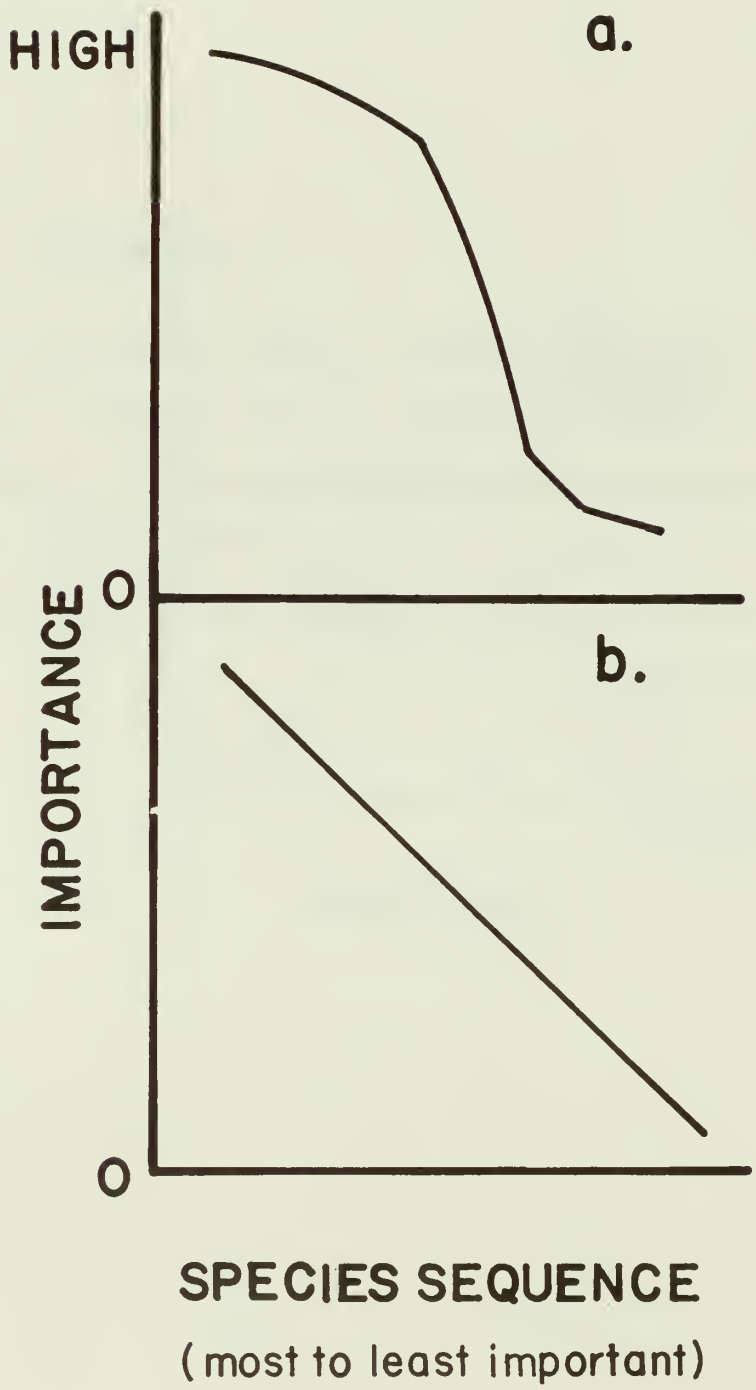
HIGH
a.
0
b.
IMPORTANCE
0
SPECIES SEQUENCE
(most to least important)

Figure 3. Two-dimensional rarity diagrams for the cases shown in Figures 2a and 2b. Each dot represents one species. These rarity diagrams have the same format as Figure 1. In 3b, rarity is only arbitrarily distinguished; in case 3a, the situation is clearer.

many
a.
O
b.
SITES
O
many
INDIVIDUALS

rarity (Fig. 1). As this figure shows, "locally abundant", "rare and local", and "scarce" are arbitrary positions within this field. The definition of rarity itself (dotted line in Fig. 1) is also arbitrary (see discussions in Dowhan and Craig 1976, Drury 1974, Fairbrothers and Hough 1972, Hardin 1977). Specific information concerning population size and number of known locales is, in any event, preferable to descriptive phrases. This introduces another problem: It may be difficult to define where one population begins and another ends (i.e., the number of distinct locations of plants). In some cases, this problem may be insolvable; in any case it is a matter of scale and careful description of the actual distribution of individuals may be required. Such deliberations point to one conclusion: No absolute and universally applicable definition of rarity can be expected (Dowhan and Craig 1976).

The clearest situation for the definition of rarity occurs when there is a steep drop-off in numbers of populations and numbers of individuals at some point along a sequence from common to rare species (Figs. 2a and 3a, after Whittaker 1972). When the species sequence shows only a gradual decline, the definition of rarity is arbitrary (Figs. 2b and 3b), and the species deemed rare are only so in relation to the abundance of other species (Dowhan and Craig 1976). For most regions, we lack this quantification of abundance and rarity.

Endangerment. Endangerment can be defined in two ways (which, it is hoped, will coincide in the long run): the legal sense (i.e., the plants declared endangered by the Secretary of the Interior under the Endangered

Species Act or state listed plants for which there is state legislation) and the biological sense (i.e., a species likely to become extinct due to the operation of relatively short-term factors currently recognized in the environment). The definitions of "endangered" and "threatened" from the Endangered Species Act of 1973 are:

Endangered: In danger of extinction throughout all or a significant portion of its range.

Threatened: Likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

The actual threats and degree of population decline help amplify our use of these terms.

Two other necessary terms are:

Extinct: A taxon formerly but no longer in existence.

Extirpated: Locally extinct; the local region under consideration is a category peculiar to the study at hand; it may be a park, county, state, or other region, as long as the taxon question is extant beyond the boundaries of the region reported on.

The adjectives, "possibly", "probably", and "presumed" may be used with "extinct" and "extirpated" to distinguish degrees of certainty about the disappearance of a species (NEBC 1972; Committee for Tennessee Rare Plants 1978). "Possibly extirpated" implies that the plant has not been seen in some time and that there has not been much recent field work or that there is some uncertainty as to the original location of the plant.

"Probably extirpated" implies that all evidence, including recent field work, points to extirpation. "Presumed extirpated" implies that original sites are well known and have been diligently searched without turning up the plant in question. The Tennessee state list used "possibly extirpated" for plants that had not been collected in 20 years, according to herbarium labels (Committee for Tennessee Rare Plants 1978). This stimulated the forwarding of information on plant relocations to the Committee, since field botanists had the added incentive to document the continued existence of a plant in the state flora (Eugene Wofford, personal communication).

It should be clear that endangerement is an actual condition of species or populations. It is hoped that all biologically endangered species will also be declared as such in a legal sense and therefore have protection by law; but due to the newness of the federal legislation, we cannot be assured legal and biological determinations will always agree. We should, in any case, always turn to the biological reality. Is the species endangered? To what threats is it vulnerable?

GUIDELINES FOR RARE AND ENDANGERED SPECIES REPORTS

The Introduction. The introduction of a rare and endangered species report should present the methods of those preparing the lists. It should include a discussion of the histories of botanical explorations, reports, and collections; of preservation and conservation efforts; of threats of human disturbance, development, and land use as they pertain to rare and endangered species; and of extinction and extirpation. The introduction should also review definitions of rarity and endangerment and previous lists of species drawn up for the study area. Major sources of information,

including reference works, knowledgeable individuals, and location of plant collection should also be cited. A statistical summary should be presented of the species contained in the report. Useful categories for statistical summaries are: families, list categories, geographic affinity, habitat restrictions, number of herbarium records, population status, and significance of local populations. Some examples are given in White (in press, a).

The major goal of the report is to record a particular taxon at a particular location at a particular time. All these variables need definition and documentation. Phrases such as "extirpated from", "endemic to", and other descriptions of habitat restriction and endangerment are necessarily keyed to specific geographic regions. The study area, therefore, should be well defined. Indeed, rare and endangered species reports are concerned with a variety of information, some absolute (the rarity of a narrow endemic), some relative to the study area (the rarity of a plant common elsewhere or the local operation of existing or potential threats). Thus, absolute and relative factors should be clearly distinguished.

The Main Text. The following describes the information that should be cited for each plant in the main text of the report. Six sections are proposed, each with subcategories:

1. Nomenclature, listed status, and taxonomy
    a. Nomenclature, including synonymy and original literature citation
    b. Legal and listed status
    c. Description and recognition

2. Distribution and habitat
    a. General distribution and geographic affinity
    b. Habitat and habitat restrictions within the study area
3. Rarity: number and size of populations
    a. Herbarium records, field sightings, and verification of sites
    b. Population status
    c. Significance of local populations to local distribution
4. Endangerment and current management, protected status, or other human influence.
5. Management and recommendations, including prioritization
6. Bibliography and other sources of information

Much of this information can be presented in tabular form; suggested tabular format is included later. Whatever the presentation or format, users should be able to find the original sources easily (for example, herbaria with important collections should be listed).

Sensitive information that might lead to the exploitation of species due to disclosure of actual sites should not be included but is appropriate for archival storage. The level of summary suggested here does not require detailed descriptions of site location, although such information is crucial in more detailed reports and in monitoring efforts.

Following discussion of these information categories, a prioritization scheme is presented. A prioritization scheme is needed to define and separate some of the categories. In particular, numbers 1b (listed status), 2a (geographic affinity), 3a (known populations), 3b (population status), 3c (significance of populations), and 4 (endangerment) are used in the

scheme. It is felt that these categories contain different kinds of information and that each must be weighed in setting priorities. Lack of clear separation of these categories, or failure to include them, is the single most apparent factor that weakens rare and endangered species reports.

1. Nomenclature, Listed Status, and Taxonomy

1a. Nomenclature

A currently accepted scientific binomial with authorship must be listed. The original publication of the name should be cited (sources for this information include Index Kewensis, the Kew Bulletin, and the Gray Card Index). If the type locale is known and pertinent to the study at hand, it should be listed. Synonymy is often important to avoid confusion (e.g., Habenaria species of the standard floristic manuals are listed as Platanthera species on the Smithsonian national endangered and threatened list; see Clarkson 1976). In some cases there are alternatives of rank for rare or endangered species (e.g., the rare taxon Carex ruthii Mackenzie may be listed in manuals under this name or under the name Carex muricata var. ruthii (Mackenzie) Gleason). The search for synonymy cannot always be exhaustive but should include all names likely to cause confusion--i.e., those names used in standard floristic manuals, rare and endangered lists, recent monographic works, and alternate treatments indicated by herbarium label annotations.

A basic aim of species protection is the preservation of unique genetic variation present in discontinuous units, whatever the taxonomic rank assigned these units (Mathews 1977). Taxonomic and nomenclatural distinction

is, at present, our only practical measure of this "uniqueness". Species and the intraspecific ranks of variety and subspecies are often listed in rare and endangered reports (Mathews 1977). Variety and subspecies are considered equivalent in the botanical literature, and some recommend the use of the latter designation exclusively.

"Forms" are not usually listed; however, one form is listed by Countryman (1978). These may be fleeting, extremely local, environmentally produced, or of uncertain genetic status; they may be due to chance circumstances or indefensible as discrete morphological entities. Hybrids are often ignored; some suggest listing them if they are relatively old in origin and persistent, not if they are chance hybrids (Mathews 1977).

A common name should also be given. In some cases these may be coined if none is given in floristic manuals (e.g., "purple-based sedge" for Carex purpurifera). As arbitrary as this may be in some cases, it nevertheless increases the readability of the report for many users.

One dilemma is whether unique plants (e.g., Psilotum, Ginkgo, Sequoia) or aesthetically appealing plants (e.g., Lilium, Epigaea repens, Cypripedium acaule, Arisaema atrorubens) warrant listing if they are not rare or immediately endangered. Private and commercial exploitation do threaten some; these could be straightforwardly listed (see "endangerment" below). The NEBC reports have categories for such species (NEBC 1972). Protection efforts are praiseworthy for these species, but they are a separate endeavor from investigations of rarity itself; hence, they are excluded from the context of this discussion. However, the inclusion of such species by others may be important. Some of these species are already protected in many national parks by provisions against the taking

of any wildflowers.

A second dilemma is whether introduced species ought to be considered for listing (e.g., as in Pittillo ms.). Nearly all lists are concerned with native plants and their rarity. Many rare introduced plants are weedy and common in other parts of the world, are present only in human-created habitats, or are not persistent as elements of the flora. They are not considered for inclusion here.

1b. Legal and Listed Status

The rare and endangered status as it appears on national lists (Smithsonian 1975; Ayensu and DeFillips 1978; Kartesz and Kartesz 1977; in Federal Register publication; Convention on International Trade in Endangered Species Appendices), state, or local lists should be stated. For example:

Cacalia rugelia (Chapm.) Barkley and Cronquist--Nationally threatened (Ayensu and DeFillips 1978); endangered in Tennessee (Committee for Tennessee Rare Plants 1978); endangered in North Carolina (Cooper and others 1977).

The report itself may add a separate designation pertinent to the study area at hand.

1c. Description and Recognition

There should be a summary of field characters, optimum dates for collection, comparisons with closely related species that might be confused with the taxon in question, and references to standard floristic manuals, monographic works, and illustrations. If the species is considered one that is easily overlooked because of inconspicuousness (e.g., Botrychium species) or because of a cryptic (hidden) life stage (e.g., annuals or

saprophytes (e.g., Monotropsis)), this should be reported. It should also be noted if the species is avoided or undercollected because of difficult taxonomy (e.g., species of Rubus and Crataegus) or because of close resemblance to a more common species (NEBC 1972).

If it is suspected that the group containing the rare taxon is in need of taxonomic revision, this should also be noted (Colorado Ecology Consultants, Inc. 1978).

In addition to the above, the description should include such basic information as plant family and life form (e.g., tree, shrub, woody vine, herbaceous plant; autotroph, saprophyte, or parasite) (Massey and others 1978).

2. Distribution and Habitat

2a. General Distribution and Geographic Affinity

The geographic distribution of taxa may be summarized by one of the following categories. These categories do not represent kinds of rarity or kinds of endangerment. They are potentially independent of rarity and endangerment and hence an important independent measure of the over-all priority of a listed species. The categories are:

Endemics - Species confined to a particular region, based on any political or natural boundaries (e.g., Calamagrostis cainii is endemic to Mount LeConte; Cacalia rugelia is endemic to Great Smoky Mountains; Houstonia montana is endemic to North Carolina). The narrowness of endemism should be noted--both for the general range of the species and also the degree of restriction to the study area (see Holland and Schramm, in press).

Species Rare Throughout - Plants that are nowehere common and not endemic to an area that is pertinent to the study area (e.g., Cladrastis lutea is scarce throughout its range, a range that does not qualify it as an endemic, disjunct, or peripheral species in the Great Smoky Mountains).

Disjuncts - Plants that are found at isolated stations remote from their main range. Disjuncts grade into peripheral species (see below). There is no discrete line of separation. If an arbitrary distinction is drawn, the definitions employed should be stated.

Peripheral or Range Limit Species - Plants that are at or near their limit of range. Geographic affinity of peripheral species should be listed.

Other - Some plants will not fit the categories established above with reference to the study area.

Not only should these categories be recorded, but a complete reference to the range of the species in question should be stated, such as relative narrowness of endemic status and the geographic affinity of disjuncts and peripherals. In many cases the latter plants can be described as "northern", "eastern", "western", or "southern", and in other cases by kinds of habitat. Sources of information for such plant distribution are given in Clarkson (1977).

The term "relict" is sometimes used (Dowhan and Craig 1976; DuMond 1973) to designate species formerly widespread and now restricted in range to changing environment and/or accidents of history. This implies knowledge of the paleohistory of an area and that the plant in question has

historic--in addition to current environmental--reasons for existence at a site. In a strict sense, it is not a kind of geographic distribution pattern. Such plants are endemics, disjuncts, or peripherals and can be listed under those categories.

It should be clear that the use of these terms is relative to the region under consideration and to taxonomic treatment. For example, a plant considered a disjunct in one region may be a peripheral species in another. Nearly all southern Appalachian species are endemics in one sense--they are endemic to North America. If a disjunct population in a study area is given taxonomic rank, it becomes an endemic. Junus trifidus var. monanthos (Jacq.) Bluff and Fing. is thus a southern endemic. If this variety had gone unrecognized, populations might have been treated as disjunct from the northern populations of Juncus trifidus L.

2b. Habitat and Habitat Restrictions

The local habitat(s) of the species should be described. A plant often is rare because its habitat is rare in a given region. Categories of habitat restriction that often result in rarity in forested, steeply drained mountain regions (like GRSM) are:

Elevation range (e.g., extreme elevations for the area)

Bedrock types (e.g., limestone)

Special soil types

Unusual edaphic situations (e.g., wet sands)

Ponds

Wetlands

Seepage areas

Cliffs

Rocky woods

Rich woods

Successional habitats (e.g., grassy balds in the southern Appalachians, including those initiated or maintained by natural disturbance).

In many cases, plants are not habitat restricted--their rarity cannot be explained simply because their habitat is rare. They are not common, even in their prime habitat (which itself may be common) and may not always be present there. They may be designated as "seemingly not habitat restricted." Jenkins (unpublished manuscript) distinguished two categories of rarity: I - plants as rare as their rare habitats, and II - plants rarer than their rare habitats. As habitats become rare, isolated, and small, we can expect island biogeographical considerations (Diamond 1975) to result in much Category II rarity, even if no other factors are operating. For example, problems of dispersal and high local extinction rates may explain Category II rarity in Jenkins' sense (Hooper 1971; Terborgh 1974).

A short, concise description of general habitat requirements throughout the species range should be made. Major factors controlling plant distribution are:

(1) Temperature regime

(2) Moisture regime

(3) Bedrock and soil conditions

(4) Disturbance regime and role in succession

Specific temperature and moisture regime data are often lacking, hence distribution of plants with relation to these factors is usually given in terms of elevation, topography (slope aspect, slope position, slope angle),

community type, and habitat.

The dynamics of natural and human disturbance and succession are particularly important to assess in relation to rare species populations (White and Bratton, in press). For example, GRSM has a predominantly forested landscape; many listed species are characteristic of open sites which are potentially threatened by seemingly natural successional processes (White, in press, a).

3. Rarity: Number and Size of Populations

3a. Herbarium Records, Field Sightings, and Verification of Sites

Herbarium records are, of course, often the only documentation to the presence of particular species on a particular site at a particular time. They are the raw material on which taxonomic opinions are based. Hence it is crucial to find the pertinent herbaria and inventory their collections relative to the study area. All herbaria label data are necessary--name of collector and his/her collection number (this is the most convenient way to refer to a particular collection); date of collection; location; comments on the identification of the specimen; determinations; and the name of the person who made the determination, if given. Inventorying the collections is time-consuming and often damaging to the collections themselves (White, in press, b). Hence, all data presented should be recorded the first time the collection is inventoried.

Field sightings and unsubstantiated reports should also be recorded. Verification of field sites should be indicated when it has been accomplished. These records can be summarized in general reports; the full information is appropriate for archival storage.

3b. Population Status

The number of stations known and estimates of population size for each station should be given, if available. If the population is declining, stable, increasing, or thought to be cyclic or erratic or to have declined to a critically small size, this should be noted. For each population and for the species as a whole, extirpation should be recorded. Any known general historic trends in the populations should also be indicated.

Flowering, fruiting, seed reproduction, and vegetative reproduction should be noted for populations visited in the field.

As with herbarium records, this information can be broadly summarized in reports. Full documentation should be filed with archival material.

3c. Significance of Local Populations

The number of populations within the study area should be compared to the total number of known populations to give an estimate of the significance of the local populations to the survival of the species. Note which, if any, of the populations are currently protected and which are in jeopardy.

4. Endangerment

Endangerment and Current Management, Protected Status, or Other Human Influence

The vulnerability or fragility of species differs and this may be independent of their rarity. Categories include:

Commercial exploitation - edible plants, medicinal plants, ornamental or cultivated plants, educational and scientific plants, or other;

Private gathering - edible plants, medicinal plants, ornamental or cultivated plants, educational/scientific collection, or other;

Human influence on habitat - drainage changes, agricultural, pollution, tourism, or other;

Human destruction of habitat - dams, mining, and quarrying; development (tourism, urbanization, industrialization, roads); or other;

Population imbalances of native animals (e.g., browsers, grazers, or pollinators);

Natural disturbance or succession;

Climatic changes;

Natural extinction/extirpation (i.e., small populations subject to natural fluctuations).

Suspected threats should be listed. The IUCN list (1976) and the five kinds of threats listed in the Endangered Species Act of 1973 should be consulted. The latter can be summarized: habitat destruction, overutilization, disease or predation, inadequacy of existing regulation, and other natural or man-made factors. At Great Smoky Mountains National Park, the principal threats are exotic pests and diseases, exotic animals (the European wild boar), exotic plants, commercial exploitation (gathering of Panax quinquefolium and species of Orchidaceae), succession, recreational uses, park developments, and large populations of a native browser (white-tailed deer) (White and Bratton, in press). Some threats are species specific; others, such as habitat destruction, are general.

One concept that can be considered in determining endangerment is "site tenacity", proposed by Adamus and Clough (1978). It is defined as the tendency of a population to persist on a site and has applications in assessing habitat importance for bird colonies. Adamus and Clough (1978)

suggested that natural areas should be designated for areas with species of high site tenacity. This concept is difficult to measure, but species with low site tenacity may indeed be vulnerable species.

Finally, the past and present management or lack of it (including protection) for the species in the areas under study should be stated.

5. Management Recommendations

Recommendations should be discussed for monitoring plant populations and threats, for future research, and for changes in management policies. Prioritization is essential--one scheme for determining species rank is discussed below.

Prioritization. Given a list of significant rare plants, a system of priorities must be established to guide further work. Such a system, using seven scalars, is being developed for GRSM. The seven factors are: (1) listed status, (2) geographic affinities, (3) significance of local populations to distribution as a whole, (4) number of locations in the study area, (5) number of individuals per population, (6) population status in the study area, and (7) suspected threats. The scalar values are shown in Table 1. The scalar values are assigned on the basis of published lists, basic floristic manuals, herbarium records, and preliminary field investigations. Many values must be estimated at the outset and revised as the work proceeds.

Plants of national significance (invariably endemics and plants rare throughout their ranges) are of higher priority than plants of only state or local significance (which are dominantly peripheral or habitat restricted species) (Factor 1). Within a given study area, endemics are more important

Table 1. Scalar values for factors used in prioritization of rare vascular plant research at GRSM.

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1. LISTED STATUS

   National list - 1
   State list - 2
   Local rarity - 3

2. GEOGRAPHIC AFFINITY

   Endemics - 1
   Generally rare - 2
   Disjuncts - 3
   Peripherals - 4
   Other - 5

3. SIGNIFICANCE OF GRSM POPULATIONS

   All known populations - 1
   All state populations - 2
   50% or more of state county records - 3
   Other - 4

4. LOCATIONS IN GRSM

   1 location - 1
   2-5 locations - 2
   6-10 locations - 3
   11+ locations - 4

5. POPULATION SIZE IN GRSM

   Very few individuals or unknown - 1
   More individuals - 2

6. POPULATION STATUS

   Declining or unknown - 1
   Erratic or cyclic - 2
   Stable - 3
   Increasing - 4

7. THREATS

   Suspected immediate and ongoing - 1
   suspected long-term - 2
   None suspected - 3

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than plants with other distributions, given equivalence in other ranking factors (Factor 2). The degree to which the species is limited to the study area may also be important (Factor 3), but there must be consideration of the piecemeal attrition of populations if no one region is more important than others in preservation of the species. Actual rarity in numbers of individuals and populations (Factors 4 and 5), population trends (Factor 6), and threats (Factor 7) are all obvious factors in ranking. In summary, the highest priority species are thus endemics, found in few and small populations, which are experiencing threats and population decline. Such species are usually nationally listed. The need for immediate action in the study area may be further underscored if the species is significantly restricted to the study area (Factor 3).

It often happens that an endemic is abundant locally or that the rarest plants in a region are peripheral species or habitat restricted species common elsewhere. This is the reason for using several independent factors in prioritization and why the information categories have been distinguished in the main text of this report. Separate kinds of rarity and endangerment can thus be distinguished.

The R E V D-T Code. Rhoades and Williams (in EGG Inc. 1977, 1978) presented a method of summarizing rarity and endangerment in coded form modified from the California Native Plant Society. The code uses four scalars (scalar values in parentheses):

R - rarity (0 - 4)

E - endangerment (0 - 4)

V - population vigor (0 - 3)

D - distribution (0 - 3)

T - tolerance to disturbance (0 - 3)

R summarizes relative number of sites and relative size of populations. E summarizes degree of endangerment. V summarizes trends of the population. D summarizes over-all distribution (i.e., narrowness of endemic distribution with reference to the study area and surrounding region). T summarizes relation of the species to disturbed sites (scalar values indicate a range of situations from "thrives on disturbed sites" to "never found on disturbed sites").

Several of these variables are related to those presented here. R has been divided into two components (number of sites and population size--Factors 4 and 5). E is similar to Factor 7. V is equivalent to Factor 6. D is similar to Factor 2. T has not been used in the prioritization scheme of Table 1, though information related to disturbance has been recommended in the discussion above. Both the R E V D-T code and the present prioritization scheme suggest ranking based on rarity, endangerment, population trends, and distribution.

Other Management Needs. Typical management needs include definition of critical habitat and optimum conditions for survival, monitoring schemes to quantify population changes, analysis of threats, and work in species biology and natural history. The manager needs to know if the species requires some kind of maintenance, habitat protection, habitat interference, or prevention of exploitation. While much of this information may be unknown, recommendations for present action and data collection should be clearly spelled out.

Monitoring of populations (i.e., the establishment of permanent sampling plots and photographic documentation) is the single most important kind of research currently needed (White, in press, a). Establishment of a

monitoring program will provide the basic data necessary for future decision-making and priority-setting. The lack of previously established monitoring programs contributes to the tentativeness of current rare and endangered species reports.

6. Bibliography and Sources of Information

Sources of information for the report should be listed in this section, including published works, unpublished materials, herbaria consulted, and personal communications.

FORMAT OF REPORTS

The tables on the following pages give a suggested format for the information outlined above. Four sections are considered:

1. Summary tables in which the species are listed alphabetically (Tables 2 - 4)
2. Lists of species by list categories (Table 5).
3. Outline of the main text of the report for each species (Table 6).
4. Outline of archival material (Table 7).

The table legends and abbreviations explain the examples. This format is being used at GRSM.

SUMMARY

We are at a new era in conservation--the intentional preservation of specifically designated rare species. This paper seeks to present a discussion of the kinds of information appropriate for rare and endangered species reports. In so doing, an attempt has been made to distinguish and discuss concepts of rarity, endangerment, distribution, and other parameters relating to the endangered species problem.

Table 2. Summary table of information on rare and endangered species: flowering dates, references in standard floristic manuals, and other data.

SPECIES	National/State Status	Flowering Dates	References Rad.	Fern.	Gleason	Avoided or Easily Overlooked	Taxonomic Problems	FAMILY
Abies fraseri	TN-SC	May-June (R)	40	53	1:59			PINACEAE
Adlumia fungosa	NC-E	May-Sept. (DS)	482	682	2:200	x		FUMARIACEAE
Agrostis borealis var. americana	NC-E TN-SC	July-Aug. (R)	110	163	1:647		x	POACEAE
Amelanchier sanguinea	TN-T	April-May (DS)	564	763	2:377			ROSACEAE
Angelica atropurpurea	NC-E	May-June (R)	786	1102	2:634			APIACEAE

Key: NC-North Carolina state list (Cooper et al. 1977); TN-Tennessee state list (Committee for Tennessee Rare Plants 1978); E-endangered; T-threatened; SC-special concern; R-Radford et al. 1968; DS-data sheets on file at GRSM; Rad.-Radford et al. 1968; Fern.-Fernald 1950; Gleason-Gleason 1952.

Table 3. Summary table of information on rare and endangered species: significance of GRSM populations to distribution as whole as reported in state lists; geographic affinity; Habitat restriction in GRSM; general habitat; forest vs. open habitat; relationship to natural disturbance.

SPECIES	National/State Status	State	GRSM Co.'s	Total Co.'s	Geogr. Affinity	GRSM H-restrict.	General Habitat	Forest/ Open Hab.	Natural Disturbance
Abies fraseri	TN-SC	TN	S	2	END-SOAPP	High	Spruce-fir	F	+, -
	Boreal forests and balds, high mts, 9 co.'s (Rad.)								
Adlumia fungosa	NC-E TN-T	NC TN	H BCS	5 5	GEN-RARE	Not	Rocky Woods	F/O	?
	Moist coves and rock outcrops, rare, mts., 5 co.'s (Rad.)								
Agrostis borealis var. americana	NC-E TN-SC	NC TN	-- --	2 1	DISJ-N	Wet	Balds, Wetlands	O	?
	Heath balds, very rare, 2 co's (Rad.)								
Amelanchier sanguinea	MTN-T	TN	SB	2	DISJ-N	Low	Rocky Woods	F	?
	Upland rocky woods, rare, 1 co. (Rad.)								
Angelica atropurpurea	NC-E	NC	H	1	LIM-N	Wet	Wet	O	?

Key: NC-North Carolina state list (Cooper et al. 1977); TN-Tennessee state list (Committee for Tennessee Rare Plants 1978); E-endangered; T-threatened; SC-special concern; S-Sevier Co.; H-Haywood Co.; B-Blount County; C-Cocke County; END-Endemic; SOAPP-Southern Appalachians; GEN-RARE-generally rare throughout range; DISJ-disjunct; N-northern species; LIM-peripheral species at range limit; High-restricted to high elevations; Not-not habitat restricted; Wet-wetlands; Low-restricted to low elevations; F-forested habitat; O-open habitat; Rad.-Radford et al. 1968.

Table 4. Summary table of information on rare and endangered species: herbarium records and field verification.

SPECIES	National/State Status	Herbarium	Total Records	Duplicates	Counties	Recently Verified in GRSM
Abies fraseri	TN-SC	GR	7	0	HSW	x
		UT	5	0	SW	
		WC	1	0	W	
Adlumia fungosa	NC-E	GR	10	1	BCHS	x
	TN-T	UT	13	7	BCHS	
Agrostis borealis	NC-E	GR	1	0	B	x
var. americana	TN-SC	UT	0			
Amelanchier sanguinea	TN-T	GR	2	0	S	x
		UT	1	0	S	
		PSW	1	0	B	x
Angelica atropurpurea	NC-E	GR	0			
		UT	0			
		WC	0			

Key: NC-North Carolina state list (Cooper et al. 1977); TN-Tennessee state list (Committee for Tennessee Rare Plants 1978); E-endangered; T-threatened; SC-special concern; GR-herbarium of Great Smoky Mts. National Park; UT-herbarium of the University of Tennessee); WC-herbarium of Western Carolina University; PSW-collections of Peter S. White; H-Haywood Co.; S-Sevier Co.; W-Swain Co.; B-Blount Co.; C-Cocke Co.

Table 5. Lists of species by national and state categories of rarity with cross referencing.

North Carolina State List (Cooper et al. 1977)
PERIPHERAL SPECIES
Endangered
Adlumia fungosa (TN-T)
Agrostis borealis var. americana (TN-SC)
Angelica atropurpurea
Arabis laevigata var. burkii
Asplenium ruta-muraria
Botrychium matricariaefolium (TN-SC)
Campanula aparinoides (TN-SC)

Key: TN-Tennessee State List (Committee for Tennessee Rare Plants 1978); T-threatened; SC-special concern.

Table 6. Check list of information categories.

1. Nomenclature, Listed Status, and Taxonomy

   1a. Nomenclature including:

   binomial with authorship
   original literature citation
   synonymy

   1b. Legal and listed status

   1c. Description and recognition

   field characters
   optimum collection dates
   comparisons with closely related species with which it might be confused
   references to standard manuals and monographs
   keys
   whether there is need for taxonomic revision in the group
   whether the taxon is avoided or easily overlooked

2. Distribution and Habitat

   2a. General distribution and geographic affinity

   2b. Habitat and habitat restrictions

3. Rarity: Number and Size of Populations

   3a. Herbarium records, field sightings, and varification of old sites

   3b. Population status

   3c. Significance of local populations to total distribution

4. Endangerment and Current Management, Protected Status, or Other Human Influence

5. Management Recommendations, including Prioritization

6. Bibliography and Sources of Information

Table 7. Information for storage in archival files.

Label data from herbarium records
Mapped population locations
Documentation of field sighting data
Photographs
Photocopied material from standard floristic manuals and monographs, including illustrations
Historical records of plant
Correspondence
Miscellaneous material

Rarity is distinguished from endangerment: Rarity is a condition of the relative numbers of individuals and populations in the study area. Endangerment is the condition of being vulnerable to extinction. Rare and/or endangered taxa represent unique and distinct genetic material. They may be endemics in the study area or may be of several other types of distribution (disjuncts and peripherals). They are sometimes rare because of the regional rarity of their habitat. Their populations may be stable, increasing, decreasing, cyclic, or erratic. They may be subject to a variety of threats. These and other parameters are useful in rare and endangered species reports. Some parameters are absolute; others are relative to the definition of the study area at hand. The emphasis should be placed on biological realities in all attempts to create rare and endangered species lists.

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